

Sole Inventor

Docket No. 20063/10008

"EXPRESS MAIL" mailing label No.
EL 995 293 045 US

Date of Deposit: December 22, 2003

I hereby certify that this paper (or fee) is being deposited with the United States Postal Service "EXPRESS MAIL POST OFFICE TO ADDRESSEE" service under 37 CFR §1.10 on the date indicated above and is addressed to:
Commissioner for Patents, P.O. Box 1450,
Alexandria, VA 22313-1450


Charissa Wheeler

APPLICATION FOR UNITED STATES LETTERS PATENT

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that I, **Ki Min LEE**, a citizen of the Republic of Korea, residing at 750-12 38/3 Daerim 3-dong, Yeongdeungpo-gu, Seoul, 150-073, Korea have invented a new and useful **METHODS OF PREVENTING OXIDATION OF BARRIER METAL OF SEMICONDUCTOR DEVICES**, of which the following is a specification.

METHODS OF PREVENTING OXIDATION OF BARRIER METAL
OF SEMICONDUCTOR DEVICES

TECHNICAL FIELD

[0001] The present disclosure relates to semiconductor fabrication and, more particularly, to methods of oxidation of barrier metal of semiconductor devices.

BACKGROUND

[0002] In fabricating semiconductor devices, titanium nitride (TiN) is generally used as a barrier metal layer for via holes or as an inorganic antireflective coating (hereinafter referred to as “ARC”) layer. For example, U.S. Patent 6,133,142 to Tran et al. uses an ARC layer formed of TiN or Ti-TiN. As another example, U.S. Patent 6,518,668 to Cohen uses a barrier metal layer comprising Ti or TiN_x. However, TiN may be oxidized in a following process. For example, the TiN may be oxidized during an ashing process that removes photoresist. The oxidized TiN may cause an increase in contact resistance, thereby degrading operational characteristics of the device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Figs. 1a through 1d illustrate, in cross-sectional views, the results of process steps for forming a barrier metal layer and an ARC layer of a semiconductor device.

DETAILED DESCRIPTION

[0004] Example methods of preventing oxidation of a barrier metal layer and an ARC layer that substantially obviate one or more problems due to limitations and

disadvantages of the related art are disclosed herein. One example method prevents a barrier metal layer and an ARC layer from being oxidized by forming $\text{Ti}_{(1-x)}\text{Al}_x\text{N}$ as a barrier metal layer and an ARC layer. The $\text{Ti}_{(1-x)}\text{Al}_x\text{N}$ is formed by adding aluminum to TiN. The barrier metal layer and the ARC layer formed of $\text{Ti}_{(1-x)}\text{Al}_x\text{N}$ have good oxidation resistance, thereby improving device reliability.

[0005] As disclosed herein, one particular example method includes forming a via hole on a substrate, depositing $\text{Ti}/\text{Ti}_{(1-x)}\text{Al}_x\text{N}$ as a first barrier metal layer on the bottom and sidewalls of the via hole by means of a plasma chemical vapor deposition, and filling the via hole with a plug material to form a via plug. The example method may further include performing a planarization process to flatten the via plug, depositing a second barrier metal layer and a metal line in sequence on the substrate including the via plug, and depositing an ARC layer of $\text{Ti}/\text{Ti}_{(1-x)}\text{Al}_x\text{N}$ on the metal line by means of a plasma chemical vapor deposition. In such an example, the second barrier metal layer may be formed of TiN or $\text{Ti}/\text{Ti}_{(1-x)}\text{Al}_x\text{N}$.

[0006] In depositing $\text{Ti}/\text{Ti}_{(1-x)}\text{Al}_x\text{N}$, the plasma chemical vapor deposition may be performed using TiCl_4 , AlCl_3 , Ar, N_2 , and H_2 gases at a temperature between about 400 °C and 500 °C and a radio frequency (RF) power between 40W and 60W under a pressure between 1 Torr and 2 Torr. Here, a ratio of $\text{H}_2/\text{N}_2/\text{Ar}$ is preferably between 20/5/50 standard cubic centimeter per minute(sccm) and 40/10/50 sccm. The “x” in $\text{Ti}_{(1-x)}\text{Al}_x\text{N}$ has a value between 0.5 and less than 1.

[0007] Referring to Fig. 1a, a via hole is formed in a substrate. After the via hole is formed, $\text{Ti}/\text{Ti}_{(1-x)}\text{Al}_x\text{N}$ as a first barrier metal layer 10 is deposited on the bottom and sidewalls of the via hole using, for example, a plasma chemical vapor deposition process.

[0008] Referring to Fig. 1b, after the first metal layer 10 is deposited, the via hole is filled with a plug material 12, which may be, for example, tungsten or aluminum, to form a via plug.

[0009] Referring to Fig. 1c, a planarization process such as chemical mechanical polishing (CMP) is performed to flatten the plug material 12.

[0010] Referring to Fig. 1d, a second barrier metal layer 11 and a metal line 15 are deposited in sequence on the substrate including the via plug. Afterwards, an inorganic ARC layer 17 is deposited on the metal line 15. In one example, the second barrier metal layer 11 is formed of $\text{Ti/Ti}_{(1-x)}\text{Al}_x\text{N}$ or TiN and the inorganic ARC layer 17 is formed of $\text{Ti/Ti}_{(1-x)}\text{Al}_x\text{N}$. TiN and is deposited by means of a physical vapor deposition (PVD) or a chemical vapor deposition (CVD).

[0011] The $\text{Ti}_{(1-x)}\text{Al}_x\text{N}$ may be formed, for example, by adding aluminum to TiN, which has been conventionally used as a barrier metal or ARC. The first barrier metal layer and the ARC layer formed of $\text{Ti/Ti}_{(1-x)}\text{Al}_x\text{N}$ provide good resistance to oxidation.

[0012] The process disclosed herein can improve device reliability by controlling continuous oxidation of the barrier metal layer using $\text{Ti}_{(1-x)}\text{Al}_x\text{N}$ formed by addition of aluminum to TiN. In addition, by using N_2 instead of NH_3 in the plasma chemical vapor deposition process, the disclosed process can provide a uniform nitride composition.

[0013] Although certain example methods are disclosed herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers

every apparatus, method and article of manufacture fairly falling within the scope of the appended claims either literally or under the doctrine of equivalents.